

Final Technical Report

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Title: *Coordinated Parameterization Development and Large-Eddy Simulation for Marine and Arctic Cloud-Topped Boundary Layers*

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The goal of this project was to compare observations of marine and arctic boundary layers with (i) parameterization systems used in climate and weather forecast models, and (ii) two and three dimensional eddy resolving (LES) models for turbulent fluid flow. Based on this comparison, we hoped to better understand, predict, and parameterize the boundary layer structure and cloud amount, type and thickness as functions of large scale conditions that are predicted by global climate models.

The principal achievements of the project were as follows

- (1) Development of a novel boundary layer parameterization for large-scale models (Grenier and Bretherton 2001) that better represents the physical processes in marine boundary layer clouds. This parameterization has been implemented and validated in regional simulations of the subtropical northeast and southeast Pacific Ocean stratocumulus regimes using the MM5 mesoscale model. (McCaa et al. 2002 a,b), and sensitivities to horizontal and vertical grid resolution as well as microphysical assumptions about the cloud droplet concentration have been documented. It gave considerably better distributions of cloud and cloud-radiative forcing than all four boundary layer schemes currently used in MM5. I have also implemented this in NCAR's Community Climate Model, where it also produces fairly realistic subtropical stratocumulus regimes, but do not yet have submitted results since I need to improve the performance of the scheme in stable boundary layers over high-latitude land masses.
- (2) Comparison of column output from the ECMWF global forecast model with observations from the SHEBA experiment. Overall the forecast model did predict most of the major precipitation events and synoptic variability observed over the year of observation of the SHEBA ice camp. Principal findings were (a) that the forecast model's representation of sea-ice thermodynamics was oversimplified, resulting in extreme damping of day-to-day surface air temperature and humidity swings during the Arctic winter, and (b) that for temperatures between -30 C and 0 C, the model clouds are often primarily ice-phase when the observed clouds are often primarily composed of supercooled water droplets. The observational data used included mm-radar, lidar, soundings, surface turbulent and radiative-fluxes, and surface precipitation (snow and rain) and led to the first attempt at producing an integrated dataset for the atmospheric portion of the SHEBA column. The first finding directly fed into the development of an improved land surface scheme called TESSEL now used operationally by ECMWF, the second helped lead to changes in ECMWF's ice microphysics scheme although a good solution has not yet been found.

Publications supported in whole or part by this grant

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